OBSERVATIONS ON THE TERTIARY FLORA OF AUSTRALIA, WITH SPECIAL REFERENCE TO ETTINGSHAUSEN'S THEORY OF THE TERTIARY COSMOPOLITAN FLORA.

By Henry Deane, M.A., F.L.S., &c.

In my Presidential Addresses to the Linnean Society of New South Wales for 1896 and 1897 I mentioned that I had devoted some attention to Australian fossil leaves, and I expressed the opinion that Baron von Ettingshausen's naming of the specimens handed over to him from Dalton and Vegetable Creek was not reliable and that his theory of the Tertiary Cosmopolitan Flora had not only not been proved but that the evidence was rather in the direction that each fossil type possessed representatives in the existing Flora of Australia. I have been urged to pursue this matter, and to aid me in my investigations have been kindly furnished with a loan of specimens by Mr. R. Etheridge, Junr., Mr. W. S. Dun and Professor Baldwin Spencer.

Before undertaking to criticise the work of so eminent a palæontologist as Baron von Ettingshausen one ought to be very sure of the ground on which one stands, but I have become so thoroughly convinced of the general correctness of the conclusions which I have indicated above, and I have received so much sympathy and encouragement from the gentlemen above mentioned and from others to whom I have explained the facts as they appear to me, that I have no hesitation in submitting to this Society a paper on the above subject.*

* See also Prof. Baldwin Spencer in the Summary of the Horn Expedition, p. 160.

The general result of the investigation so far has been to throw the greatest distrust on the theory of the "Cosmopolitan Flora," which is, briefly stated, this, that the Tertiary Floras of different countries contained the same types and were closely allied and resembled one another much more than the Tertiary Flora of any particular country resembles its existing flora. In the recent period the floras of different regions have acquired their distinctive characters, due chiefly to climatic influences, and the old types which at one time were universally distributed have disappeared in some regions and not in others. Thus with regard to Eastern Australia, the Tertiary Flora is said to contain representatives of the existing floras of all other parts of the world now absent from Australia, and in like manner the Tertiary Flora of other parts of the world, as, for example, Europe, contains, it is asserted, representatives of genera and orders such as *Eucalyptus*, *Casuarina*, *Leptomeria*, *Exocarpus*, *Proteaceæ*, &c., which are now practically confined to the Australian region, or in the case of *Proteaceæ*, to Australia and South Africa.

The theory has worked a great deal of harm. It has been published in text books as an undisputed scientific truth, and the fact is lost sight of that it exists only in the opinion of a certain school, among whom are to be counted those who, not having time to investigate the matter themselves, look upon the statements of Ettingshausen as sufficient authority to encourage them in their belief: while other botanists and palæontologists equally entitled to respect look upon the evidence adduced in its favour as altogether unconvincing. One need only study Zittel's "Palæophytologie" to find upon what shaky foundation the determination of the Australian types in European Tertiary beds rests, and it is therefore all the more lamentable to see in text books of highest repute such statements as that in Eocene times forests of Eucalypts waved in England and that the vegetation was largely of an Australian character, while on the other hand in Australia during the Tertiary Period forests of oak and beech flourished.

It will be my endeavour to show that it is unnecessary to seek outside Australia for the types of our fossil flora. Since writing the Presidential Addresses referred to, a further study of the subject has led to the conclusion that changes in range and distribution of the Australian flora have taken place since the Tertiary, and that consequently to some extent the character of the vegetation has been modified. This is evident from a casual inspection of the fossils from Vegetable Creek, Gunning, Wingello, Bacchus Marsh, &c. The more luxurious flora now confined to strips and patches of the coast must have formerly spread over the table land, and there seems to have been, during the period when these fossils were embedded, a moister and perhaps warmer climate, one less liable to the severe droughts that we have to endure at the present time. A difference in climate such as this would adequately account for whatever variation may have taken place in the character of the vegetation. With advancing cold from the south and droughty conditions from the west the more luxuriant flora would retreat to the warmer and damper districts, and many species, genera and perhaps orders might be completely killed out, especially in the south.

The flora of Australia has been shown to be composed of three elements which are chiefly developed if not exactly predominant in the sub-regions named by Professor Spencer Torresian (northern and eastern), Bassian (south-eastern), and Eyrean (central and western). The Torresian flora, which Mr. Hedley calls Papuan, is more or less intimately connected through New Guinea with the Malayan and South-eastern Asiatic flora; it flourishes under conditions of warmth and moisture. It is looked upon by Professor Tate as exotic in character and as belonging properly to the Oriental Region.

The conditions requisite for the Bassian element of the flora seem to be moderation of temperature, if not actual cold, accompanied by damp. This element shows affinities with certain New Zealand and South American plants, and is treated by Professor

Tate as Andean in origin and introduced. The Eyrean sub-region is one over which dry conditions largely prevail, and those conditions may now help to protect the flora from the inroads of the coast vegetation. Professor Tate treats the flora of this region as the truly indigenous one. He divides the Continent into three, the Euronotian on the east and south, which on the coast partially amalgamates with the two introduced elements of Oriental and Andean character, the Eremian in the centre and the Autochthonian of the south-west.

Referring again to Professor Spencer's subdivisions, which more nearly illustrate the views which I have to put forward, it is clear that if the range of climatic conditions varied, so that drought and moisture, heat and cold were differently distributed, the divisions between the floral sub-regions would take up different positions. Such a change seems to have taken place in the past, and the climate having been then moister it is probable that there was formerly a much larger area over which the two eastern elements, and especially the Torresian, predominated and the sway of the western element was restricted. When the centre of Australia was largely lacustrine, and hot winds and drought were less of a feature in the climate, the Torresian element of the Flora might readily be supposed to extend as far as this and there would at that time have existed a luxuriant vegetation, one of the last relics of which is the Central Australian Palm, *Livistona Mariæ*. My contention is that, though the distribution may then have been different, the same general types were then all the same, and whether Torresian, Bassian or Eyrean, were consequently just as truly Australian then as now. A return to the same conditions would be followed immediately by a march to the westward of the brush vegetation of the coast, the aggressive character of which is, I am informed by Mr. Hedley, insisted on by settlers on the more northern rivers, and it would require little encouragement to again clothe parts of the tableland and western slopes in its ancient luxuriance.

In the "Contributions to the Tertiary Flora of Australia" of Baron von Ettingshausen, English translation published by the

Department of Mines, I find four important statements summarising the author's conclusions :—

(*a*) He says (p. 3)—"The Tertiary Flora of extra-tropical Australia is, as regards character, essentially distinct from the present living flora of Australia."

(*b*) "It has also much more similarity to the Tertiary Floras at present known than to the existing flora of Australia."

(*c*) "The characteristic plants of Australia are but feebly represented."

(*d*) Then (p. 4) he says—"The genera *Myrica*, *Betula*, *Alnus*, *Quercus*, *Fagus* and *Salix* are characteristic of the European and North American floras; the *Castanopsis*, *Cinnamomum*, *Tabernæmontana*, *Premna*, *Elæocarpus* and *Dalbergia* point to East India and China; *Magnolia* especially to the warmer parts of North America; *Bombax* to tropical America; *Knightia* and *Coprosma* to Oceania."

The first questions that arise after reading (*a*), (*b*) and (*c*) are, what does Ettingshausen take to be the character of the existing flora of Australia, and what are the characteristic plants of Australia that he refers to?

There can be little doubt that in speaking of the "character of the existing flora of Australia" he is altogether ignoring the very important coastal element, which is indeed at the present time spread over a comparatively small area, but is very rich in genera and species, and that his "characteristic plants of Australia" are certain well known types of *Proteaceæ*, such as *Banksia*, *Dryandra*, *Lomatia*, *Grevillea*, *Hakea* and *Persoonia*, and a few genera belonging to other natural orders, such as *Eucalyptus*, *Casuarina*, *Leptomeria*, *Exocarpus*, &c.

If Baron von Ettingshausen had possessed any profound knowledge of the distribution of plants in Australia, would he have attributed so much importance to the results of his inquiry? He no doubt means that, because in the specimens sent to him to examine, *Eucalyptus*, *Banksia* and other peculiar Australian types do not make up the majority, a radical change is indicated. But this view is incorrect. I have pointed out

above that what is now the coast climate must have extended further inland, and no doubt embraced the districts from which the fossils are obtained. If any deposit derived from the brush vegetation of the coast as it now exists could be preserved in the same way as the Vegetable Creek and Dalton deposits, we should find *Eucalyptus*, *Banksia*, &c., only in a small minority, as those types do not flourish in the "brush." Why, then, should we expect to find them abounding in the Tertiary Beds of Dalton and Vegetable Creek?

We now pass on to the consideration of proposition (*d*). Ettingshausen maintains that *Myrica*, *Betula*, *Alnus*, *Quercus*, *Fagus* and *Salix* are found and these are characteristic now of Europe and North America. It is to be remarked that *Quercus* is not only found in Europe and North America, but extends at the present time to Africa, South America, the south and east of Asia, the Philippines and Malay Archipelago, and even to New Guinea, which is in the Australian region. *Fagus* has four representatives at the present day in Eastern Australia and Tasmania, and three in New Zealand, so that the selection of *Quercus* and *Fagus* to prove the Baron's point is most unhappy. It may be mentioned that *Fagus* is also just as much at home in Patagonia. It remains to be seen whether the forms attributed to *Myrica*, *Betula*, *Alnus* and *Salix* can be only such and nothing else. *Castanopsis*, *Cinnamomum*, *Tabernæmontana*, *Premna*, *Elæocarpus* and *Dalbergia* are said to point to East India and China. The genus *Cinnamomum* has representatives at the present day in Queensland and even New South Wales, and the so-called characteristic *Cinnamomum* venation is equally strongly developed in certain species of *Litsæa* and *Cryptocarya* now growing in Queensland and New South Wales; *Tabernæmontana* and *Premna* have species in New South Wales and Queensland; *Elæocarpus* has many representatives at the present day in New South Wales; and *Dalbergia* is represented in Queensland. There remains, therefore, nothing but the alleged *Castanopsis* to prove this part of the Baron's proposition. The question is, cannot this fossil be otherwise explained than by referring it to *Castanopsis*? *Magnolia*,

he says, points to the warmer parts of North America. It will be necessary to see whether these leaves are not equally referable to existing species of Australian plants. *Bombax* is said to point to tropical America; the fact was not known, or it was overlooked, that the genus is represented at the present day in Northern Australia.

Knightia and *Coprosma* are said to point to Oceania. In passing, it is to be remarked that the leaf named *Knightia* is a very poor fragment. *Knightia* is one of two genera of *Proteaceæ* indigenous to New Zealand, the other being *Persoonia*. Each contains one species only in New Zealand, *Knightia* being peculiar to it. *Persoonia* has many Australian representatives. The example is not a happy one. If the ancestors of *Knightia* and *Persoonia* have not been introduced fortuitously from Australia by wind or ocean currents, or by birds, which is not altogether impossible, it is probable that these *Proteaceæ* may have spread through the more or less fleeting Antarctic connections, proof of the existence of which is continually accumulating. *Coprosma* is a genus well represented in Eastern Australia at the present day; ten species are known to exist in that region.

It is to be supposed that Ettingshausen has brought his strongest examples forward, but it will be seen from the above how essentially weak the arguments adduced are; and if it can be shown, as I believe it will be, that the so-called leaves of *Myrica*, *Betula*, *Alnus*, *Salix*, *Castanopsis* and *Magnolia* do not necessarily belong to those genera, the whole fabrication created by Ettingshausen, at least as regards Australia, falls to the ground, and the reference by Heer, Ettingshausen and others of European fossil plants to Australian genera becomes also liable to doubt.

In a future paper I propose to deal with these special cases and some others suggested by the perusal of the "Contributions to the Tertiary Flora of Australia."

I wish to add a few words with reference to the reputed existence of Eucalyptus and other types, now peculiar to the Australian region, in beds of Tertiary Age in England and Europe.

Although accepted as a fact by some eminent men and adopted in the text books, the evidence is considered altogether inadequate by many others whose opinions command respect, so that it is not improbable that if the follow-my-leader practice were discarded and each writer took the opportunity of judging for himself, there would be a general acknowledgment that the assumptions rest on altogether insufficient grounds. The writers in Zittel's valuable work "Palæophytologie" throw doubt on a great many of the determinations of Ettingshausen and his school. It seems to be conceded, indeed, that the existence of *Eucalyptus*, which most of the specimens do not absolutely prove, receives strong support from the case of *E. Geinitzii* in the Cretaceous, as leaves, flowers and fruit approximating to those of *Eucalyptus* have been produced, the fruits indeed separate, but the leaves and flowers on the same stalk. Now, however, we have in Dr. Newberry's posthumous work on the Amboy Clays (Monographs U.S. Geol. Survey, Vol. xxvi.) a statement that the author has discovered Heer's fruits of *E. Geinitzii* in great abundance, that he has no doubt whatever of their being identical with Heer's specimens, and that he has proved them not to be those of any species of *Eucalyptus* at all, inasmuch as they are flattened, not round as they ought to be if of that genus, and that he has obtained them attached to a core of a cone, evidently that of a conifer (see p. 46 of the work referred to). Clearly the so-called fruits have been improperly assumed to be associated with the leaves and flowers, and without them the value of the evidence is almost nil, for the leaves and flowers might easily belong to something else quite different. According to Zittel's work, the evidence on which the existence in Tertiary times of *Casuarina*, *Leptomeria*, *Exocarpus*, and various *Proteaceæ* rests is equally unreliable. In passing, attention may also be called to the remarkable resemblance that exists between the leaves of certain species of *Myrica* and those of *Banksia* and *Dryandra*.

It is not to be understood that doubt is thrown on the former existence of a sub-tropical flora in the south of England and even further north, or on the existence of *Araucaria* and *Sequoia* in

countries where they do not now exist, as they were then representatives of an already ancient and widespread group of Conifers. The objection raised is against the probability of there having lived in those parts the peculiar dicotyledonous types of the Australian region.

There are further considerations which point to the great improbability of the existence of *Eucalyptus* in the Cretaceous of the Northern Hemisphere. *Eucalyptus* belongs to a natural order in which the leaves are normally opposite. That the ancestral forms of that genus possessed opposite leaves is inferred from the fact of the leaves being so arranged in seedlings; in many species the change to long and alternate leaves only takes place after several years' growth; in some species, such as *E. melanophloia*, the opposite character persists throughout life. These facts seem to point to the probability of the pendent, leathery leaves alternately placed being an adaptation to conditions of drought, and in support of this supposition it has been pointed out that where species have failed to produce the vertically hanging leaves, another expedient has made itself apparent, namely, that they have not only become thick and leathery, but protected with a coating of an oily excretion giving them a glaucous appearance. The flowers themselves have lost the power of producing petals except as such may be represented in the deciduous operculum, and this gives a still stronger hint of the whole plant having become modified in the course of long ages to resist drought, whereas its closest congeners, *Tristania* and *Angophora*, which have petals, are confined respectively entirely to the coast districts or to damper situations on the eastern side of Australia, not having been able to penetrate very far into the droughty interior. These being the facts, is it likely that a genus so highly specialised to resist drought should have lived in Europe so far back as the Cretaceous? There also arises the question, if *Eucalyptus* flourished in England and Europe in the Cretaceous and Tertiary, and, if the Cosmopolitan theory is trustworthy, throughout the world in the latter age, what possible conditions could

have caused its extinction everywhere else but in the Australian region? Surely it should now be growing naturally somewhere on the confines of the deserts and drier districts of Asia, Africa, or America if droughty conditions help it along. On the other hand, different species of Eucalypts have adapted themselves in Australia to all conditions of moisture and dryness, heat and cold, and there is certainly nothing in the climate of other parts of the world to show why the genus should have been killed out in every corner, especially as quite a large number of species have been tried and have been found to flourish in New Zealand, at the Cape, on the Pacific Coast and elsewhere in America, and on the Mediterranean.

The probability of the former existence in Europe of any forms now characteristic of Australia is in like manner extremely small, and it requires the very strongest evidence—not the mere opinions of men however eminent—to establish such a fact. On the other hand, the probability of their having been evolved in the region where they now most abound is very great. A glance at the geological history of the past will be found instructive.

At the end of the Devonian and beginning of the Carboniferous periods, the *Lepidodendron* flora was in full vigour and apparently distributed throughout the world. Then took place a remarkable change in the Southern Hemisphere. Arctic or glacial conditions, or such at least as produced all the phenomena attributed to glaciation, set in. The *Lepidodendron* flora was swept away from a large area of the surface of the globe and the *Glossopteris* and *Gangamopteris* flora took its place. This area included what we now know as South Africa, Australia, the southern extremity of South America and Southern India. Judging by the identity of the flora throughout and its dissimilarity to that of the rest of the surface of the earth, this area must have contained land surfaces more or less continuous and altogether separated by some important barriers from the world outside. This land has been named by Suess "Gondwana Land."

It is evident, therefore, that at the end of the Palæozoic Age lands now widely separated by the ocean must have been con-

nected by land and separated from the rest of the world. What an opportunity for the developments of special forms of life! We begin with Glossopteris and Gangamopteris—we only want time for the higher orders.

The land connection continued into the lower Mesozoic when the fresh-water Karoo series of South Africa, the upper Gondwana system of India, and the Ipswich and Clarence coal measures of Australia, and the Argentine Mesozoic beds ranging from Trias to Jurassic were laid down. *Tæniopteris* and *Thinnfeldia* were widely distributed.

If South Africa and Western Australia remained connected till well into the Mesozoic Age, what a likely region for the *Proteaceæ* to have originated in! In South Africa and Australia the suborder *Vacamentaceæ*, which in Bentham's opinion show archaic characters, has its stronghold; the other great group, the *Folliculares*, including the *Banksieæ*, may be assumed to have developed in Australia after its separation from South Africa. That this combined land has been the centre of distribution seems probable. From here a few have passed northwards in Africa, and later on, by means of Tasmania and the somewhat fleeting Antarctic connection with South America, members of the suborder *Folliculares* have found their way into Patagonia and Chili.

The existence of such a centre explains perhaps better than any other theory the distribution at the present day of the two allied groups of *Ericeæ* and *Epacrideæ*, which some botanists have included in one natural order, and which, judging by their affinities, have probably originated in a common ancestor. The *Ericeæ* have spread north to the Mediterranean and beyond; the *Epacrideæ* to the islands to the north and east of Australia.

There are some peculiarities about the distribution of certain groups of the *Leguminosæ* which look like parallelism between South African and Australian development; in both these countries the *Leguminosæ* are remarkable for the number of their species; the *Rutaceæ* present a similar case, for the tribe of *Boronieæ* of Australia finds its parallel in the *Diosmeæ* of South Africa. Many other similar examples exist. The *Casuarineæ*, to

judge by its present distribution, must have originated in the Australian region, as, with the exception of some endemic species in the neighbouring islands, no species exist which are not Australian and which are not likely to have been transported as seeds by ocean currents.

The capsular-fruited *Myrtaceæ*, although like the groups abovementioned specially fitted to flourish in South Africa, are nevertheless not found there. They probably, therefore, did not exist in what is now Western Australia till after the land connection with South Africa had broken up. Perhaps the most likely theory would be that they originated in Northern or North-eastern Australia, arriving at their greatest development afterwards in Western Australia, while the fleshy-fruited section of *Myrtaceæ* became differentiated at a later date (probably by natural selection) and spread northwards and westwards into Asia and Europe. In connection with the suggested origin of the Myrtaceæ in Northern Australia, it is to be remarked that as one proceeds south to Victoria and Tasmania, although certain species of Eucalypts attain an enormous development and stature, the species become fewer in number, and other genera which flourish further north disappear altogether.

When we look at the enormous development that has taken place in the zoological series since the beginning of the Tertiary, and still more since the Jurassic Period, when the first Dicotyledons made their appearance, it would seem strange if great changes should not have taken place in the highest orders of the Vegetable Kingdom. The great groups of Reptilia and Batrachia, which had their highest development in the Mesozoic Age, have taken up since the beginning of the Tertiary a subordinate position; and the Aves and Mammalia, which were before the latter period set in in the infancy of their development, are now the dominant orders; and what extraordinary evolution between the beginning of the Tertiary and the present time! Is it not probable that some considerable development has also taken place in the highest orders of plants? It may be quite possible that the great groups, and

even some of the principal natural orders, were already developed in the Jurassic Period; but have we any right, except on the most convincing evidence, to assume that existing genera had already commenced their career? There is no hesitation on the part of some palæontologists to class remains of plants of Cretaceous Age under the genera *Quercus*, *Fagus*, *Acer*, *Aralia*, *Cinnamomum*, &c., as the case may be; but is it wise to do so? It seems to me that the possibility of great changes has been underestimated. The late Baron von Mueller examined and described a considerable number of fossil fruits from the Pliocene Gold Leads of this Colony and Victoria. Not one of them corresponds with any existing fruit, and the affinities of many of them are exceedingly doubtful. Surely these facts imply change of great amount; and if so much has taken place since the Pliocene, what may not have occurred when the whole Tertiary series is taken into account?

What, therefore, I wish to suggest is that though the general character of the vegetation may have remained the same for some considerable time past, and though we are dealing in a fossil state with what are no doubt the ancestors of the existing vegetation, we have no right to assume that the ancestor of an oak had in every respect the character of the modern genus Quercus, or that the ancestor of *Cinnamomum* in the Miocene would if it could be examined be found to correspond with the description of the modern genus *Cinnamomum*. It might have been the ancestor of three or four other genera as well, and so have some of the characters of each combined. Apart from this, we have the difficulty of determining what existing plant the fossil leaf really resembles; it may resemble those of half-a-dozen plants of widely different groups, and after looking into the matter one must become convinced that it is far safer to give to a fossil a name denoting resemblance rather than to dogmatically state that such a leaf is that of *Alnus*, *Cinnamomum*, &c. If Ettingshausen had contented himself with naming his specimens *Alnites*, *Cinnamomites*, &c., the proceeding would have been free from objection, but then the cult of the Cosmopolitan Theory would have received no impetus.